Northwest Weather and Avalanche Center

Mountain Weather Glossary

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- **Adiabatic processes—**an adiabatic process (thermodynamic) is one in which heat does not enter or leave the system. Because the atmosphere is compressible and pressure varies with height, adiabatic processes play a fundamental role in meteorology. Thus, if a parcel of air rises it expands against its lower environmental pressure; the work done by the parcel in so expanding is at the expense of its internal energy and its temperature falls...despite the fact that no heat leaves the parcel. Conversely, the internal energy of a falling parcel of air is increased and its temperature raised as a result of the work done on the air in compressing it.
- **Adiabatic lapse rate—**the rate at which an air mass changes internal temperature when it is either lifted (temperature cools) or lowered (temperature rises) with no other heat entering or leaving the system. The dry adiabatic lapse rate (DALR) is typically followed by ascent or descent of a relatively dry air mass and is ~10ºC/km or ~1ºC/100m [~3ºC or 5.4ºF/1000 ft]. When moisture is present in the parcel and the parcel is lifted to its lifting condensation level, latent heat release during condensation provides some warming to the air mass when the vapor within the parcel condenses into cloud droplets. This moist or saturated adiabatic lapse rate (SALR) is dependent on temperature and pressure, but at lower levels in temperate latitudes is about half of the DALR due the heat released. It can be estimated as ~6ºC/km or .6ºC/100m [~2ºC or ~3.6ºF/1000 ft]. Such process driven lapse rates may differ significantly from actual local *lapse rates* obtained by radiosonde/balloon measurements.
- **Advection—**the horizontal transfer of an air mass (atmospheric) property such as moisture and temperature by the wind. Cold air advection indicates cold air being horizontally transferred across space by the virtue of motion of that air mass (by pressure effects and resulting wind).
- **Air flow**—generally refers to the upper level circulation pattern and direction of primary upper level winds. When used in conjunction with adjective describing meteorological type (e.g., warm, moist, cool) and direction (e.g., northerly) of associated prevailing wind, this term broadly categorizes air moving into a given area. At time air flow is used for describing motion and type of both upper and lower level air masses [e.g., onshore flow of moist low-level air, a strong southwesterly flow aloft, etc].
- **Air mass**—regions of the lower atmosphere possessing like meteorological qualities (e.g., humidity, temperature) over a large area. Air masses affecting the Cascade or Olympic mountains may be (according to source of origin) maritime tropical, maritime polar, or continental polar. These may vary from warm and moist to cold and dry with often quite distinct boundaries or zones separating the different air masses. See also inversion.
- **Albedo (surface reflectivity)**—a measure of the reflecting power of a surface, i.e.,the ratio of the amount of energy reflected by a body compared to the overall amount it receives. This reflective power is typically expressed as a percentage, e.g., new snowfall has a very high albedo (on the order of 90%+) while the albedo for wet or old snow can drop to 40-60%. See

this wet snow article for a description as to how albedo plays an important part in wet spring avalanching.

- **Anti cyclonic**—in the northern hemisphere, clockwise circulation of air flow around a center of high pressure. Typically the air flow spirals slowly outward from a surface high in a clockwise fashion (in the absence of terrain effects) due to frictional effects. However away from the surface, upper winds flow clockwise approximately parallel to the iso-heights of a particular pressure surface (geostrophic balance—or balance between horizontal pressure gradient force and the horizontal component of the Coriolis force).
- **Arctic air**—a type of air mass whose characteristics are developed mostly in winter over arctic surfaces of ice and snow. Arctic air is cold aloft and may extend to great heights...but the surface temperatures are often higher than those of polar air...which is usually shallow in comparison. The intrusion of arctic or modified arctic air into the Northwest normally requires a blocking offshore ridge and an associated north to northeasterly flow of air from relatively high latitudes that pulls cold air southward from the interior of northern Canada or Alaska. This cold and dry high density air typically pools in the Columbia River Basin of eastern Washington and Oregon. This pooling results in very cold surface temperatures along the Cascade east slopes and dramatic temperature inversions over the Cascade crest and passes when surface low pressures approach the area from the west and warm, moist lighter air from the southwest overruns cold air at the surface.

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- **Backing winds—**winds that shift counterclockwise with time at a given location (e.g., from south to southeast) or shift direction with differing height (e.g., west at the surface and southwest at 850 or 500 mb). Backing winds are common with time at a given location before a warm front (south winds in the morning becoming southeast later in the morning), while veering winds are likely with height at the same location (south or southeasterly winds at the surface but southwest or west winds aloft). The opposite of *veering winds*.
- **Blocking**—the obstructing, on a large scale, of the normal west to east progress of migratory cyclones (also known as lows, fronts and storms). A blocking situation is associated with pronounced meridional (northerly or southerly) flow in the upper levels, and typically remains nearly stationary or moves slowly westward with time, often persisting for a week or more. Common blocking situations include a rex block (upper closed high over upper closed low) and omega block (upper flow follows an omega or Ω type pattern where a closed upper high is in the middle of the upper part of the omega).
- **Bora—**a strong, dry downslope wind whose source of origin is often so cold that the air temperature remains cold despite *compressional* warming (*adiabatic* warming) as the air mass descends on the lee of the mountain range.

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- **Cap cloud—**a cloud that forms around the summit of a mountain and is produced by forced upward lift of a moist layer in the atmosphere as the layer encounters the mountain.
- **Channeling**—the convergence of (moisture laden) air by gradually narrowing valleys to produce locally increased precipitation or increased wind flow (locally higher wind speed).

- **Chinook**—a warm, dry wind on the lee side of a mountain range, the warmth and dryness due to adiabatic compression upon descending the mountain slopes. The exact local nature of Chinook (or foehn) winds varies widely and depends on a variety of factors including the local topography, the strength of the basic flow across the mountains, the amount of moisture lost through precipitation on the windward side, and conditions prior to the onset of the chinook.
- **Closed low**—see *cut-off low*.
- **Closed high**—see *cut-off high*.
- **Cold front**—see *front*; also the leading edge of an advancing cold air mass that is lifting and displacing the warmer air in its path. Generally, with the passage of a cold front, the temperature and humidity decrease (the air mass behind the cold front is descending), the pressure rises (colder air in depth weighs more), and the wind shifts in a *veering* pattern (usually from the southwest to the northwest in the Northern Hemisphere). The bulk of precipitation occurs at and/or behind the front, often arrives as bands of heavier precipitation, and with a fast-moving system, a squall line may develop ahead of the front. Although temperatures normally drop behind the front, the cool air contained within the easterly flow common near the passes prior to frontal passage (east to west pressure gradient brings cold air from the surface toward the passes) may actually be colder than the air behind the cold front—hence in this instance the air mass may actually warm somewhat following cold frontal passage.
- **Compression**—increased wind speeds near higher ridges are often produce by compression and resultant acceleration of the air mass; also, compressional heating of an air mass may result in warming and drying of an air mass as it sinks to lower levels
- **Condensation nuclei--** microscopic particle of dust, smoke or salt that allows for condensation of water vapor to water droplets in the atmosphere. Nucleus for the formation of a rain drop. Condensation normally occurs on these particles when relative humidity becomes 100 %. Some condensation nuclei, like salt, are hygroscopic and water can condense on them at relative humidities lower than 100 %.
- **Confluent flow**—see also *convergence*. Coming together of separate segments of upper level wind fields. When a split flow develops in the normal westerly flow pattern in the northern hemisphere, the area of separation is an example of diffluence or diffluent flow (see also *divergence*), while the region in which the flow comes together is an example of confluence or confluent flow. Confluence typically creates a stronger unified flow field.
- **Continental snow climate—**the snow climate typical in mountainous regions located far from the moderating effects of oceans. Such regions (e.g., the Rocky Mountains of Colorado, Wyoming and Montana) commonly experience relatively shallow snowpacks, cold temperatures, frequent and widespread faceting and depth hoar, and rare mid-winter rainfall.
- **Convective instability**—the physical state of an unsaturated layer or column of air which results in an unstable air mass when the column or layer is lifted bodily to the point of complete saturation. Such bodily lifting may be the result of physical processes such as solar heating of the earth and lower atmospheric layers, heat transfer from a relatively warm ocean into a cold atmosphere, or mechanical deflection by large barriers, i.e., orographic lifting producing convective instability.
- **Convective showers**—precipitation resulting from convective clouds
- **Convection**—vertical (upward) atmospheric motion that results in upward transport and mixing of atmospheric properties of heat and moisture. Free (gravitational) convection is caused only by density differences within the atmosphere and may result in cumulus clouds through differential heating of the air adjacent to land and subsequent vertical air flow (warm

air is less dense than the surrounding cooler air and so it is lifted, cools, condenses and forms clouds). Forced convection refers to vertical atmospheric motion due to mechanical forces such as frontal lifting, orographic lifting or convergence of wind flow, and this usually results in the majority of significant precipitation producing clouds.

- **Convergence**—in short, air flow into an area from more than one direction. In Washington State, if a strong westerly flow of air accompanies an unstable atmosphere, another local atmospheric phenomena resulting from convergence may also occur. Known as the Puget Sound Convergence, this weather situation occurs when air flow splitting around the Olympic Mountains comes together (converges) to the lee of the mountains over Puget Sound and is subsequently forced upward (downward motion is prevented by the ground). This convergent air cools and may condense as it rises, often creating significant showers or thundershowers in the presence of an unstable atmosphere. Caught in the general southwest to northwest flow pattern behind frontal systems, these showers or thundershower cells drift generally to the northeast to southeast (depending on the free winds between 850 and 700 mb) toward either Stevens or Snoqualmie Passes, often giving locally heavy rain or snow when further lifting occurs over the Cascades.

  It should be noted that a large barrier like the Olympic Mountain range is not required for anomalous precipitation from convergence effects. Convergent precipitation also has been documented to the lee of volcanic peaks such as Mt. Rainier and Mt. Hood; however, as in the case of the Puget Sound Convergence, a rain or precipitation shadow of anomalously low precipitation may also occur just to the lee of such obstacles. This *rain shadow* is the result of several effects, including blocking of the flow by the barrier as well as descending and drying air to the lee of the barrier.
- **Cooling trend—**a weather trend characterized by lowering freezing levels and air temperatures. Cooling trends following major warm-ups usually help to stabilize the snowpack through freezing of any liquid water in the snowpack. However, cold temperatures following snowfall may limit settlement and bonding of the snowpack (little viscous deformation of the snowpack) and may prevent unstable snow accumulations from settling or sliding until a subsequent warm-up.
- **Coriolis force**—An apparent force caused by the rotation of the earth. In the Northern Hemisphere, the effects of this force are to deflect northward moving winds to the right. Combined with the localized heating of air in the equatorial regions, heat loss at the pole and the associated hemispheric circulation cell driven by such differential heating, this force acts to produce the dominant westerly flow at upper levels in the mid-latitudes and the normal west to east progression of storms. By deflecting air moving from high pressure to low pressure, the coriolis force (in conjunction with the pressure gradient force, centrifugal forces and frictional effects) also produces the normal cyclonic circulation (counter-clockwise) around lows and anti-cyclonic circulation (clockwise) around highs. In the Southern Hemisphere, the southerly flowing air in the same thermally driven circulation is deflected to the left. Although this produces the same basic westerly current at higher elevation mid-latitude regions of the Southern Hemisphere, the coriolis deflection to the left produces an opposite sense of rotation around highs and lows.
- **Cut off low (closed low)**—a cold low which has become displaced out of the basic westerly current, and lies to the south of this current. A closed or cutoff low possesses a distinct center of cyclonic circulation which can be completely enclosed on a map by one or more isobars or height contour lines. Such lows are usually quite slow moving, can result in weak split upper

flows, and may produce substantial return flow (back-door) precipitation along the east slopes (normally leeward) side of mountain ranges such as the Cascades of Washington. However, normally such closed low features produce maximum precipitation well to the south of Washington. This feature typically starts out as a trough in the upper *westerlies*, subsequently deepening into a closed circulation that extends downward to the surface.

- **Cut off high (closed high)**—a warm upper high (area of high heights of the associated pressure surface) which has become displaced out of the basic westerly current at mid or upper levels of the atmosphere, typically lying to the north of this current. This feature forms initially as a ridge in the upper westerlies, subsequently intensifying into a closed circulation and extending down to the surface. Frequently such highs are also blocking highs, may form over a *closed low* to the south (a *rex block* pattern), and often result in a substantial split in the westerly flow where both a northern and southern branch of westerlies become active.
- **Cyclonic**—cyclonic circulation is counter-clockwise around a low pressure in the Northern Hemisphere (clockwise in the Southern Hemisphere). In either case, the sense of rotation about the local vertical is the same as that of the earth's rotation. Cyclonic flow around a low typically produces a slow vertical lifting of an air mass covering a relatively wide area (*synoptic* scale lifting), on the order of 100-1000 miles or kilometers.

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- **Deformation clouds—**normally an elongated cloud band that is formed from rising air near an area of diffluence. The clouds lie parallel to separating streamlines of current.
- **Dew point—**the temperature to which a given parcel of air must be cooled (at its existing pressure and water vapor content) in order for saturation of the air mass to occur. Further cooling of the air mass will result in water condensation on adjacent surfaces. When the temperature at which saturation of the given air parcel is below 0 degrees C, this point is called the frost point and further cooling in this case will result in ice crystal growth (e.g., frost formation or hoar frost).
- **Diffluent flow**—see also *divergence*. Refers to a usually weak or weakening upper level flow pattern characterized by separation of the wind field, resulting in a net flow of air out of the region. Such diffluence creates two separate branches of the previous singular flow (*split flow*). An area of diffluence is characterized by weak or weakening weather systems and generally light and variable winds. However, diffluence at upper levels of the atmosphere creates vertical motion from below as air must move in from other levels to maintain continuity and prevent a vacuum. Such vertical motion often result in increased clouds and a deformation cloud band that may or may not produce associated precipitation.
- **Divergent flow**—net flow of air out of a given region.
- **Disturbance**—refers to an area where weather, wind, pressure, etc show signs of the development of cyclonic circulation. The term is used to describe any deviation in flow or pressure that is associated with a disturbed state of the weather such as cloudiness or precipitation.
- **Downdraft—**evaporation of falling precipitation locally cools adjacent air and makes it denser than the air around it. This cooling air mass can acquire a significant velocity and create both vertical gustiness in the atmosphere or horizontal gusts once it reaches and spreads out laterally on the ground. Strong downdrafts and associated strong surface winds are most often associated with thunderstorms, but may also occur with strong cold fronts.

- **Dry adiabatic lapse rate—**the rate of temperature decrease when a dry (unsaturated) parcel of air is lifted (no heat exchange with the surrounding air). The rate is .98 º C per 100 meters or approximately 10º C per kilometer (or 5.4º F per one thousand feet). For a saturated air parcel, the rate of temperature decrease with lifting is moderated by the release of latent heat from condensing air; see *moist adiabatic lapse rate*.

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- **Evaporation—**the transformation of liquid water into a gaseous state (water vapor). Opposite of *condensation*.
- **El Niño—** A climatic phenomenon occurring irregularly, but generally every 3 to 5 years. El Niño is associated with cyclical warming of East Pacific Ocean sea water temperatures off the western coast of South America that can result in significant changes in weather patterns in the United States and elsewhere. This occurs when warm equatorial Pacific waters move in and displace the colder waters, cutting off the upwelling process. El Niños often first become evident during the Christmas season (El Niño means Christ child) in the surface oceans of the eastern tropical Pacific Ocean. The phenomenon involves seasonal changes in the direction of the tropical winds over the Pacific and abnormally warm surface ocean temperatures. The changes in the tropics are most intense in the Pacific region; these changes can disrupt weather patterns throughout the tropics and can extend to higher latitudes, especially in Central and North America. The relationship between these events and global weather patterns are currently the subject of much research in order to enhance prediction of seasonal to interannual fluctuations in the climate; however in general, one of the primary effects of El Niños are to split the westerlies in the east-central Pacific. In North America, the resulting split flow tends to favor cooler and wetter than normal winters across much of the southern United States, especially during moderate to strong events. See http://www.elnino.noaa.gov.
- **Environmental lapse rate—**the rate of decrease of air temperature with height, usually measured by radiosonde balloon. Such a change in temperature with height varies from place to place, from hour to hour and day to day, depending on the particular atmospheric layering and air mass properties being sampled. It refers to the actual condition of the local atmosphere as shown by the vertical temperature, wind and moisture profile obtained through the sounding process; this lapse rate may differ significantly from a physical process derived lapse rate such as the *adiabatic lapse rate*.

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- **Flow**—see *air flow*.
- **Foehn**—see *chinook*.
- **Forecast models**—differential equations of continuity that model the atmosphere and the interaction of the atmosphere with land and water are run on computers multiple times daily. Input into these models comes from wide network or surface and upper air observations. Forecast models take this initial set of conditions (both boundary and internal conditions) and extrapolate various meteorological parameters and fields (such as pressure, temperature, moisture, winds etc) out in time through application of a sophisticated set of time dependent equations. Various output fields result at a variety of different temporal and spatial scales and layers, depending on the type and resolution of the model. While hemispheric or large scale

models are the most robust, they provide less specific results. However, they provide input for smaller nested or meso-scale forecast models that have more realistic terrain features and much smaller resolutions. Accuracy at both the short (1-2 days) and intermediate term (3-7 days) of both large and smaller scale models are improving annually. And meso-scale forecast models hold much promise for better and highly specific forecasts. But such small scale models are very sensitive to errors in initial conditions and may amplify small errors tremendously.

- **Free winds**—air flow that exist within the free atmosphere, without frictional, blocking , constricting or deflecting effects produced by local topography.
- **Freezing level**—the vertical height (m or ft) in the atmosphere where the temperature reaches 0 deg C. This level may occur more than once due to vertical layering of different air masses and associated temperature inversions. Due to a time and energy delay of melting of frozen precipitation (e.g.. snow) passing downward through the freezing level, the snow level usually lies about 300 m (~1000 ft) below the freezing level, although this height difference varies considerably depending on the vertical temperature structure of the particular air mass.
- **Freezing nuclei**—ice crystal formation in the atmosphere requires the presence of tiny particulates in the atmosphere called freezing nuclei. These freezing or ice nuclei act as freezing surfaces for water droplets and include microscopic dust, salt or soil particles lifted from the earth by wind. Without freezing nuclei, water droplets can remain in liquid form down to -40°C; water that exists in liquid form at below freezing temperatures is called *supercooled* water. Freezing nuclei sizes range from 0.5 to 8 um in diameter and are not that common—only about 1 in 10^8 airborne particles is effective as an ice nucleus at -20degC. For example, at -10°C only one in a million water droplets freeze, at -30°C one in a thousand freeze. However, at -40°C all droplets freeze spontaneously.
- **Front**—a boundary region between different air masses in which large horizontal gradients in weather (e.g., temperature, wind, humidity) often occur. Fronts are classified through their direction of motion. If the air mass on the cooler side of the front is advancing into the region formerly occupied by warmer air, the front is termed a cold front. Similarly if the air mass on the cooler side is retreating and being replaced by warmer air, the front is a warm front. Other variations include an *occluded front*, *stationary front*, and *arctic front*.
- **Frontal system**—a system of fronts as they appear on a weather map (synoptic chart). This includes: a continuous front and its characteristic along its entire length, including its warm, cold, stationary and occluded sectors and its variations in intensity.
- **Frontal wave**—a horizontal wave-like deformation of a front in the lower levels, commonly associated with a maximum of cyclonic circulation in the adjacent flow pattern. The first sign of the formation of a new depression (frontal wave) occurs at some point along a cold front that is trailing after a moving mass of warmer air. At that point a spreading out of the pressure contours and a local weakening of the wind becomes apparent. A wave shaped distortion of the contour lines becomes apparent in time and a small low pressure center (surface) develops. This new feature/disturbance often grows rapidly in size, acquires a wind circulation of its own, and moves along the previous cold frontal boundary (often quickly). This transforms the region that lies before it (to the east) into a warm front, while the air behind it remains a cold front. Such development often slow or stall the motion of the parent cold front considerably.
- **Frost point—**see *dew point*.

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- **Graupel—**the German word for "soft hail". Graupel is a snowflake that has lost its original shape and become rounded through the accretion of supercooled water droplets (riming). Graupel pellets are small (typically 2-5 mm) and are easily compressible; they should not be confused with hail (which is formed by accretion of thin layers of ice/refreezing water) that is normally quite hard and ranges in size from 5 to 50 mm or more in diameter. Graupel showers in the winter may form weak layers of "ball-bearing" like snow in unusual areas since the graupel normally rolls down off steeper terrain and accumulates in lower angled terrain.
- **Gravity wave—**waves that propagate under the influence of buoyancy forces. Gravity waves include surface gravity waves, such as waves on the surface of the ocean, interfacial gravity waves, such as waves at the interface between fresh surface water and underlying salty ocean water, and internal gravity waves which propagate vertically as well as horizontally in density stratified fluid (like the atmosphere). Gravity waves (in the form of *mountain waves)* can produce high gap flow winds in the foothills along the west slopes of the Cascades (given certain environmental conditions).
- **Greenhouse effect—**natural global warming resulting from absorption and re-emission of infrared radiation by atmospheric gases (especially carbon dioxide and water vapor). Greenhouse effects on a snowpack may be very dramatic in the spring time when thin mid or high clouds allow short wave solar radiation to penetrate through to the snow surface but act to absorb and re-radiate long wave radiation back to the snowpack. This produces intense heating and melt of near surface snow and may quickly produce increased avalanche activity.

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- **High pressure (aloft)**—see also ridge, upper ridge.
- **High pressure (surface)**—also termed anticyclone or surface high. Refers to a local maximum of atmospheric pressure on the earth's surface, with the associated air mass characterized by descending or subsiding air. Surface winds circulate clockwise (anti-cyclonic) around a high pressure center in the Northern Hemisphere (opposite in the Southern Hemisphere). In general winter weather associated with anticyclones is cold and relatively dry. Also, weather associated with single, surface highs (or lows) is short lived (typically 1-2 days), while weather associated with larger-scale *long wave* upper highs (ridges) or lows (troughs) may persist for a week or more.

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- **Ice crystal—**any of the many crystalline forms of ice that result from sublimation (vapor deposition) of water molecules onto a freezing nuclei (such as dust smoke or salt). See *condensatioi nuclei*.
- **Instability shower**—a shower that is produced by local convection within an unstable air mass. Such showers are most frequent within a moist air mass that is sufficiently unstable so that (daytime) surface heating can produce well developed cumulus clouds.
- **Intermountain snow climate**—the snow climate typified by mountainous areas located in between *maritime* and *continental* regimes. Intermountain ranges may experience characteristic of both maritime and continental snow climates, depending on the particular winter. However,

in general they are characterized by intermediate snow depths, intermediate temperatures, and less frequent depth hoar and rainfall. This is also termed a *transitional snow climate*.

- **Inversion (temperature inversion)**—an atmospheric layer in the troposphere (lower layer of the atmosphere) in which temperature increase with elevation. Inversions are often due to the sinking of dense, cold air into valley floors overnight, or the overrunning of cold, easterly pass flow by a warmer, west to southwesterly flow above (common during winters in the Cascade Range of Washington). Also may result from subsidence warming of the atmosphere by compression, associated with surface high pressure.
- **Isobar**—a line of constant pressure on weather maps. Isobars lie between surface highs or lows on a surface weather map and typically enclose surface pressure features.
- **Iso-height (iso-hyetal surface)—**lines of constant height of a given (usually mid or upper level) pressure level or surface. Iso-hyetal maps are best visualized as topographical maps where lower values represent troughs or valleys on the pressure surface and higher values or heights represent ridges or peaks of the particular pressure level.

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- **Jet stream**—a band of relatively strong winds (generally greater than 100-150 km/hr) concentrated within a narrow stream in the upper levels of the atmosphere. More specifically, a quasi-horizontal flow of maximum winds imbedded in the mid-latitude westerlies and concentrated in the high troposphere (approximately 30-40,000 ft). The position and orientation of jet streams vary from day to day. General weather patterns (hot/cold, wet/dry) are related closely to the position, strength and orientation of the jet stream (or jet streams), and the jetstream is often associated with areas of maximum precipitation at the surface. A jet stream at low levels is known as a low-level jet.

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- **Katabatic (winds)—** Any wind blowing down an incline; the opposite to anabatic wind. If the wind is warm, it is called a foehn; if cold, it may be a fall wind (bora), or a gravity wind (mountain wind). A katabatic wind may also be caused by air that cools over a surface of ice, becoming heavier than surrounding air, then draining down-valley; this is also called a glacier wind.

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- **La Niña—** Condition opposite of an El Nino. In a La Nina, the tropical Pacific trade winds become very strong and an abnormal accumulation of cold water occurs in the central and eastern Pacific Ocean. For more information on climatic cycles or oscillations like La Niña or El Niño, click on this Climate Prediction Center link.
- **Lapse rate—**see also *environmental lapse rate*. The rate of change of temperature with height in the atmosphere.

- **Latitude**—the latitude of a location is a north-south reference of the position on a sphere, and on earth it is often expressed as a distance of the place to the equator, measured in degrees (º) along a circle between the two poles. Locations on the equator have zero (0º) latitude, the north pole has latitude +90º or 90º north, and the south pole has latitude -90º (or 90º south). The second coordinate needed to specify a position on a sphere is the *longitude*. [In the sky, latitude is used in the ecliptical and galactic coordinate systems. The corresponding coordinate in the equatorial coordinate system is called declination.] In weather forecasting, latitudinal or zonal flow refers to winds and storm tracks that move predominantly west to east (along lines of equal latitude), and is typically associated with relatively flat upper ridges and troughs that have minor north or south extension. In the United States, strong latitudinal or zonal flow may bring copious precipitation to mountainous maritime areas due to strong *orographic* lifting by north-south mountain ranges (e.g., Cascades and Sierra Nevada ranges).
- **Leeward**—the side or a mountain range, mountain, ridge or slope that faces away from the prevailing wind direction. For example, east exposures are lee to a west wind. Owing to wind scouring of snow from windward terrain and subsequent transport of surface snow, leeward slopes may receive up to 10 times more snow than nearby but wind sheltered valley locations. However, on a broader scale the lee sides of mountain ranges may receive overall much less precipitation than the windward sides (e.g., very wet west slopes of the Cascade range versus relatively dry east slopes).
- **Lee wave (cloud)**—sinusoidal cloud forms that form to the lee of a barrier and result from vertical oscillation of the atmosphere set in motion by interaction of upper winds and topographical barriers. Lee wave clouds may extend hundreds of miles downwind of mountain ranges or larger topographic barriers (e.g., volcanoes like Mt. Rainer, Mt Hood, etc), and are formed through sinusoidal lifting (cooling and condensation) and sinking (warming and drying) of moisture laden air. Prior to such oscillation, the air mass may be close to saturation and needs only forced lifting to cool and condense into clouds.
- **Long wave**—Large scale oscillations in the upper levels of the atmosphere that have relatively long wave lengths (on the order of a thousand kilometers) which may contain several *short wave* features. At any given time in the northern Hemisphere (or southern) there may be as many as five or six or as few as three long wave troughs encircling the globe. The position and intensity of each long wave feature generally governs general weather patterns (e.g., warm and wet or cold and dry) for periods of several days or weeks, though the effects of persistent features may last for months. For example, a long wave trough may span a large portion of the United States and have several imbedded shorter wave length troughs and ridges associated with individual and smaller scale surface highs and lows. During eastward movement of a long wave trough across the US, several individual storm systems may rotate around the flow of a strong long wave trough over the period of a week or more. Similarly, areas under the influence of a strong or blocking long wave ridge may see remnants of (dissipating) storm systems as they move through or over the long wave ridge axis.
- **Longitude**— longitude is an west-east measurement of a position on a sphere. On earth it is defined by the angle measured from a vertical plane running through the polar axis and a particular circle on Earth known as the prime meridian. A line connecting all places of the same longitude is termed a meridian and the prime meridian runs through Greenwich, England. This point of reference is 0º longitude. Since measurements are made both East and West from the prime meridian, the maximum longitude value is 180 degrees. Mathematically, longitudes are usually denoted as positive for easterly longitudes (e.g., +71º = 71 E), and negative for westerly longitudes (e.g., -65º degrees = 65 W). Latitude and longitude are both measured in degrees,

minutes, and seconds. In weather forecasting, longitudinal (or meridional) flow refers to winds and storm tracks that move primarily from south to north or vice versa (winds blowing along meridians). Such meridional flow is typically associated with relatively high amplitude upper ridges and troughs that have both significant north and south extension, and results in areas of either very warm, wet conditions (on the front or west side of a ridge) or dry, cold weather (flow down the back or east side of a ridge).

- **Low pressure (aloft)**—see also *trough*, *upper trough*.
- **Low pressure (surface)**—see also *surface trough*.

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- **Maritime snow climate—**the snow climate found in mountainous regions in close proximity to the moderating influences of oceans. These ranges (e.g., the Sierra Nevada of California, Cascade Range of Washington and Oregon) are normally characterized by deep snowpacks, moderate temperature regimes, and frequent rainfall. While well developed depth hoar is rare (more common along the east slopes of such ranges), near surface or upper level faceting of snow near rain crusts is common and surface hoar is a frequent and persistent avalanche related problem.
- **Meridian (meridional)**—also see *longitude*. The geographical meridian at any point on the earth's surface is the semi-circle which passes through the point and terminates at the geographical poles. Meridional flow refers to longitudinal flow or air along a meridian, i.e., northerly or southerly, as opposed to zonal, latitudinal or east-west.
- **Mesoscale**— atmospheric processes that occur on the spatial scale from 10s to 100s of kilometers. This size scale refers to weather systems smaller than synoptic-scale systems but larger than single storm clouds and includes smaller scale weather features that exist for minutes or hours. Examples of mesoscale atmospheric phenomena are thunderstorms, locations of precipitation convergence, tornadoes, and land-sea breezes.
- **Moist adiabatic lapse rate**—the rate of temperature decrease within a saturated parcel of air as it is lifted. This rate of decrease is not a constant like the dry adiabatic lapse rate, but is dependent on the amount of moisture within the air parcel. As moisture condenses into clouds within the parcel, the parcel is warmed somewhat by the release of the latent heat of condensation and so cools less rapidly than a similarly lifted dry parcel. A commonly used approximation for this lapse rate is around 6ºC per kilometer. Contrast this with the *dry adiabatic lapse rate* (~10ºC per km).
- **Moisture capacity**—the maximum amount of water vapor that a parcel of air can hold at a given temperature. As the temperature of a given parcel or air increases, so does the amount of water vapor that the parcel can hold prior to saturation. This moisture capacity is one of the reasons that maritime regions often receive such copious precipitation since they are often affected by relatively warm and hence very moist air masses (containing much more water vapor that can precipitate out when lifted).
- **Monsoon or monsoonal flow—**a thermally driven wind arising from differential heating between a land mass and an adjacent ocean that reverses its direction seasonally and often produces very wet or very dry seasons. Also any general flow pattern that results in unusually wet conditions or prolonged warm, wet weather.
- **Mountain wave**—the wavelike effect, characterized by updrafts and downdrafts, that occurs above and behind a mountain range when rapidly flowing air encounters the mountain range's

steep front. Mountain wave is also the generic term for all *gravity waves* occurring in the vicinity of or caused by mountains. It also specifically refers to atmospheric waves that form above, rather than behind, mountains and may produce *cap clouds*.

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- **Nuclei—**see *condensation* and *freezing nuclei*.

O

- **Occluded front**— a composite of two fronts, formed as a cold front overtakes a warm or quasi-stationary front. Two types of occlusions can form depending on the relative coldness of the air behind the cold front to the air ahead of the warm or stationary front. A cold occlusion results when the coldest air is behind the cold front and a warm occlusion results when the coldest air is ahead of the warm front.
- **Omega block**—a blocking weather pattern in the mid-latitude northern hemisphere westerly flow in which a high amplitude upper ridge develops into an omega shape (Ω). Such a stable and relatively stationary block may persist for a week or more. Contrast with a *rex block*.
- **Orographic precipitation**—precipitation which results from the forced lifting of moist air over an orographic barrier such as a mountain range. Strictly, the amount so designated should not include that part of the precipitation which would be expected from the dynamics of the associated weather disturbance, were the disturbance over flat terrain. Orographic precipitation is not always limited to the ascending ground but may extend for some distance windward of the base of the barrier (upwind effect), and for a short distance to the lee of the barrier (spillover). Generally, the lee side is characterized by the rain shadow. In the Washington Cascade Range, often 50% or more of precipitation received is due to upslope, non-frontal rain or snow.

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- **Parcel—**a small imaginary volume of air a few meters on edge used to describe meteorological processes.
- **Pineapple express—**a term describing an unusually strong and persistent west to southwest upper flow moving over the top of flat upper ridging and brings sub-tropical air northeastward (originating near Hawaii). When the flat upper ridge establishes over the Northwest, the pineapple express results in copious amounts of rain at relatively high freezing levels in the Cascades (ranging up to 4-6 inches or more of 24-hour rainfall accumulations).
- **Precipitation intensity (PI)**—amount of liquid water deposited per hour. Measurement of rate at which mass (water) is being added to the given area or location, expressed as mm/hr, cm/hr or tenths of inches/hr. For snowfall rates, see also *water equivalent*.
- **Pressure levels**—vertical levels in the atmosphere characterized by constant pressure, e.g., 850 mb pressure level (approximately 1500 m or 5000 ft), 700 mb pressure level (about 3000 m or 10,000 ft), and 500 mb pressure level (about 5600 m or 18,000 ft). Pressure levels or maps can be interpreted as topographic maps of a particular pressure surface, and are convenient reference points for describing free air winds that blow parallel to iso-heights of the particular pressure surface and impinge on mountain locations.

- **Pressure gradient**—that force due to pressure differences (usually quasi-horizontal) within a fluid (e.g., ocean or atmosphere) directed from high pressure to low pressure areas. Due to a balance of forces between the pressure gradient force, the *coriolis force*, and frictional effects, air flow moving between high and low pressure centers spiral clockwise away from surface high pressure and spirals counterclockwise inward toward surface low pressure (in the northern hemisphere). In the mountains, surface pressure gradient forces may result in local wind flow patterns (especially through passes or gaps in mountainous terrain) substantially different that might be expected on the basis of free winds alone.
- **Prog (prognosis)**—see *prognostic chart*.
- **Prognostic chart**—also termed forecast model chart or display. A chart or computer display showing the expected pattern for pressure, height, temperature, moisture, precipitation, etc over a given area at a specified future time; such displays are based on computer models and related physical equations that predict future behavior of the atmosphere.
- **Progressive wave**—usually a short wave trough or ridge which moves generally eastward through long wave features, resulting in local intensification or weakening of such long waves. Also any atmospheric feature that continues to move eastward over time. Compare with *retrograde* or retrogression.

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- **QPF (quantitative precipitation forecast)**—forecast of water equivalent for a particular location during a given time period. 24-hour and 6-hour QPF's are common.
- **Quasi-stationary**—moving very little over time. During blocking flow patterns such as rex blocks or omega blocks, associated upper level and surface features may move very little for days. These features are termed quasi-stationary or almost stationary.

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- **Radiational cooling**—cooling of the earth's surface (ground or snowcover) and the adjacent air, accomplished (mainly but not exclusively at night) whenever the earth's surface suffers a net heat loss due to long wave radiation to the atmosphere. Radiational cooling acts to cool near surface air and this can produce such atmospheric effects as low-lying fog (radiation fog), dew (cooling air near the ground can hold less moisture—excess moisture condenses onto surfaces as water or dew), or hoar frost (excess moisture in cold air near the snow or ground surface results in vapor deposition on exposed surfaces).
- **Rain shadow**—the region, typically on the lee side of a mountain range or large topographic barrier, where the precipitation is less and at times significantly less than that received on the windward side. In the Northwest, rain shadow effects are common to the east-northeast of the Olympic mountains, along the east slopes of the Cascades, and in certain situations to the east of Mt Rainier or other large volcanic peaks.
- **Relative humidity**—a measure of the moisture content of the air mass expressed in percent. This is arrived at by dividing the actual moisture content of a parcel by the maximum possible moisture content that the parcel could hold at a specific temperature.
- **Retrograde (retrogression)**—the motion of an atmospheric wave or pressure system opposite to that of the basic flow pattern in which it is imbedded. A retrograding disturbance in the

northern hemisphere moves toward the west, and retrogression involves slow westward movement of long wave features.

- **Ridge**—an elongated area of relatively high heights for the particular pressure surface, almost always associated with and most clearly identified as an area of maximum anticyclonic curvature of wind flow (or pressure height contours) at the upper levels of the atmosphere. The axis of such a feature is called the ridge line.
- **Rime—**a white or milky and opaque granular deposit of ice formed by the rapid freezing of supercooled water droplets as they impinge upon an exposed surface.

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- **Short wave**—a progressive wave in the horizontal pattern of air motion which ordinarily moves more rapidly through longer wave (length) systems, and is normally associated with a migratory cyclonic weather disturbance in the lower troposphere. Long wave troughs or ridges typically contain one or more short wave features that may act to intensify, weaken or move the parent long wave.
- **Snow level**—see *freezing level*.
- **Spillover**—that part of orographic precipitation which is carried along by the wind so that it reaches the ground in the nominal rain shadow of the lee side of the barrier.
- **Split flow**—region of the upper level westerly flow pattern that is characterized by the breaking apart or divergence of the main westerlies into two distinct directions or branches, each often having a distinct associated storm track. Such flow patterns are often associated with *cut-off* highs or lows.
- **Snow climate**—a term describing the overall weather that characterizes a given region from a snowpack and avalanche viewpoint. The three major snow climates include: *continental, intermountain or transitional,* and *maritime* with associated climates ranging from cold and relatively dry (continental) to warmer and quite wet (maritime).
- **Stationary**—refers to a weather situation or feature that is not moving (appreciably) relative to the earth's surface.
- **Storm track**—the path followed by a center of low atmospheric pressure, commonly aligned with the jetstream. Also, that geographical area lying beneath the belt of strongest upper level westerlies through which fronts are most likely to pass.
- **Subsidence**—descending motion of air in the atmosphere.
- **Sublimation**—the process of a solid (ice) changing directly into a gas (water vapor), or water vapor changing directly into ice, at the same temperature, without ever going through the liquid state (water). The opposite of crystallization.
- **Supercooled (water droplets)**—the condition when a liquid remains in the liquid state even though its temperature is below its freezing point. Also liquid water droplets between 0 and -40 degrees Celsius that would freeze immediately if particles were present to start the solidifying process.
- **Synoptic (scale)**—generally refers to regional or larger-scale meteorology of high and low pressure systems, which typically range from several hundred to a thousand kilometers. Typical weather maps are most often displayed on the synoptic scale (synoptic charts), though more recently *meso-scale* forecast models have augmented synoptic scale descriptions of the atmosphere and expected weather parameters.
- **Synoptic chart**—see *synoptic scale*.

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- **Temperature inversion**—see *inversion*
- **Troposphere**—the region of the atmosphere, immediately above the earth's surface and up to the tropopause (about 15 km thick) in which the temperature falls fairly regularly with increasing altitude, clouds form, convection is active, and mixing is continuous and more or less complete. This layer contains about 75 % of the total mass of the atmosphere. It is also the layer where the majority of our weather occurs. Maximum air temperature occurs near the Earth's surface in this layer. With increasing altitude air temperature drops uniformly with increasing height at an average rate of 6.5 degrees Celsius per 1000 meters (commonly called the Environmental Lapse Rate), until an average temperature of -55 degrees Celsius is reached at the top of the troposphere.
- **Trough (upper)**—an elongated area of relatively low atmospheric pressure aloft or local depression of a particular pressure surface, usually identifiable as an area of maximum cyclonic wind flow. The opposite of a ridge. The axis of the trough is the trough line. This term is commonly used to distinguish it from the closed circulation of an (upper) low; however, a large scale trough may include one or more upper lows, an upper trough may be associated with one or more surface lows, and an upper low may have one or more distinct upper troughs radiating from and rotating around it.
- **Trough (surface)**—an elongated area of relatively low atmospheric pressure at the surface. Surface troughs typically follow surface frontal systems and commonly move through a region just ahead of or with the associated upper trough.

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- **Unstable air—**an air mass is deemed unstable if a parcel of air within the air mass will continue to rise (and grow/expand) after initial displacement occurs. See also *instability showers* and *convection*.
- **Upper air**—see upper level; also upper air soundings typically refer to the 300-500 mb levels which encompass the jetstream and the mid-point of the earth’s atmosphere (500mb) that is a convenient and commonly used reference for comparing different forecast model runs.
- **Upper level—**generally refers to that level of the atmosphere at about the 500 mb level (1/2 way up in the atmosphere and varying between 5100 and 5800 meters or between 17,000 and 19,000 ft). This level is a common reference point for meteorologists as wind flow at this level tends to steer surface weather disturbances. Many meteorological maps describing various atmospheric parameters at this level are also produced by national meteorological centers throughout the world, so the 500-mb level acts as a common
- **Upslope fog**—a type of low cloud or fog formed when air flows upward over rising terrain and is cooled to or below its *dew point* through expansion.
- **Upslope precipitation**—see *orographic precipitation*

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- **Valley fog**—a type of fog formed when cold air draining into or accumulating in valley bottoms reaches its dew point (temperature of condensation), condenses and forms cloud. This process occurs when radiational cooling takes place. Factors favoring the formation of valley fog are: a shallow surface layer of relatively moist air beneath a dry later and clear skies, and light surface winds.
- **Vapor pressure**—the pressure exerted by a vapor when in equilibrium with its liquid or solid form. It is a measure of the tendency of a material to form a vapor and in the case of atmospheric moisture it is measure of the amount of water vapor present at a given temperature. The higher the vapor pressure, the higher the potential vapor concentration. Vapor pressure increases as temperatures increase, so warmer air can hold more vapor than colder air.
- **Veering winds—** A change in wind direction that shifts clockwise in the Northern Hemisphere at a certain location. In the Southern Hemisphere, it is counterclockwise. This can either happen in the horizontal or the vertical (with height). For example, surface winds shifting from the north to the northeast to the east, or southeast winds at the surface becoming southwesterly aloft. It is the opposite of *backing*.
- **Virga**—rain falling from the base of clouds that evaporate before reaching the ground. Virga typically forms visual streaks that extend downward from the base of clouds, and vertical wind shear may elongate virga into many different shapes (mare's tails, etc).
- **Vorticity**—a measure of horizontal wind shear in the atmosphere, or of the local rotation of winds in a weather system.

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- **Warm front**—see *front*
- **Warm-up—**a trend in weather characterized by rising freezing levels and air temperatures. Warm-ups may have a destabilizing effect on the mountain snowpack, especially if they follow a period of snowfall at cold temperatures and low freezing levels.
- **Water equivalent (WE)—**the amount of moisture received at a location expressed in terms of liquid water. This number is often expressed in inches or hundredths of inches of water in the US or mm of water elsewhere. Ten inches of snow with a water equivalent (WE) of 1 inch of water yields 10% snow (density of 100kg/m^3 or 1/10 the moisture content of liquid water). However, depending on temperature and wind conditions, the WE of this same 10 inches might range from .5 inches (5% snow or 50kg/m^3—low temperatures and light winds), to as much as 2 inches WE or more (20% snow or 200kg/m^3—high winds or warm temperatures).
- **Wave**—see *frontal wave, long wave*, *short wave*
- **Westerlies**—the predominant wind flow direction at the upper levels of the atmosphere in the middle latitudes of both the northern and southern hemispheres. These prevailing winds result from unequal heating of the earth's surface from south to north, the global circulation that results from this uneven heating, and the action of the Coriolis force on the northward moving winds at the upper levels.
- **Wind direction—**the direction from which the wind is blowing. For example, a west wind is blowing from the west, and a south wind is blowing from the south.
- **Windward slopes—**slopes facing into the prevailing wind direction. Such slopes will normally cause local wind speed acceleration as the air mass is compressed flowing up and over such

terrain. The resulting acceleration often scours new snow from such slopes and deposits the transported snow onto *leeward* terrain.

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Z

- **Zonal**—latitudinal flow, easterly or westerly; opposed to meridional which is typically northerly or southerly. Strong westerly winds at mid and upper levels are examples of zonal flow, while northerly and southerly winds extending over many degrees of latitude would indicate more meridional flow.

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Selected weather glossary links

This compilation of mountain weather related terms is based on information from many sources including:

Meteorological Glossary (1972)—D.H. McIntosh
Mountain Meteorology: Fundamentals and Applications—Dr. David Whiteman, Pacific Northwest National Laboratory, Richland, WA
PhysicalGeography.net—Dr. Michael Pidwirny, Department of Geography, Okanagan University College, BC
Weather.com Glossary—The Weather Channel web site
University of Oregon Weather Lectures—University of Oregon, Salem, OR
National Snow and Ice Data Center Glossary—NSIDC, University of Colorado Boulder, CO
Thanks also to Knox Williams of the CAIC for his glossary of National Avalanche School weather terms